Using Prefabricated Building for Addressing Housing Needs in Libya: A

Study on Local Expert Perspectives

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**Abstract:** The use of prefabricated building systems offers considerable advantages in cases wherein extensive solutions to housing problems are immediately required. However, this system’s share in the overall building housing market in Libya is nearly negligible. This study attempts to understand the current situation of prefabricated building systems and their potential to address Libyan housing conditions. The perspectives of local experts in the construction industry are mainly considered. Qualitative analysis is conducted by using interview data. Results show that prefabricated building can improve the Libyan housing industry; however, government and prospective practitioners who lack information, knowledge, and know-how of prefabricated building applications are often prejudiced against their use. Most of the interviewees also cannot fully provide conceptual guidelines, which may serve as the starting point for the evolution and development of prefabricated building in Libya.

**Keywords:** prefabricated building; perspective; the Libyan housing industry; usage; conceptual framework.

**1. INTRODUCTION**

Libya is currently constrained by housing deficit issues. Although it can be argued that similar problems are faced many other developing countries, the specific demographic trends of each country must be clearly understood. Libya is home to a small number of residents of 6,258,984 (as of 2014) even if its land area is wide at 1,759,540 km2 [1]. The demographic distribution of the Libyan population has changed from 24.2% in its cities and towns in 1954 to over 88% in 2006. In particular, 25% of the population has been concentrated in the two major cities of Tripoli (capital city) and Benghazi (second largest city) in 2006 [2]. Libya’s settlement can therefore be described as having high degrees of dominance in certain cities but intense spatial inequalities across regions.

Libya’s large size in terms of area but small in population implies that the limited human resource impedes national development. Consequently, the expatriate workforce has been indispensable in the Libyan domestic market. In the late 1980s and 1990s, the Libyan foreign policy encouraged the entry of irregular workers from African and Arab countries and allowed their extended stay [3]. However, this policy intervention critically affected the construction industry because most of the foreign workers had limited or no skills. Grifa [4] argued that labor is a major issue and a key challenge in the Libyan construction industry. The recent labor shortage, mainly in conflict areas, has resulted in the insufficient number of workers who can complete the standard projects of the construction industry.

Pressured by the skills shortage, declining number of new workforce entrants and need for faster housing completion, the construction industry has sought innovative technology based on prefabricated building to maximize productivity [5]. Prefabricated buildings may flourish with the provision of incentives and the active encouragement by the government. Moreover, any increased activity of the private sector in the housing industry, such as the sale or lease of buildings, will likely open new market opportunities for the prefabricated building sector.

However, stakeholders require guidance in re-localizing prefabricated building by engaging in secure steps rather than in unsettled leaps over a long time. Given that a detailed study on prefabricated building in the Libyan construction industry has been scarce, this study is the first attempt to explore such technology. This study aims to increase our understanding of prefabricated building concept and potential for use to respond to the housing needs in Libya, focusing on local construction experts. This study is also beneficial to countries that experience similar background difficulties, specifically developing countries that still suffer from a lack of organization in the industry. This study further aims to explore the following research questions:

• What is the current situation of prefabricated building in Libya?

• What are the key drivers and main challenges that affect the use of prefabricated building in the construction sector in Libya?

The paper begins with a brief review of concept of Prefabricated Building and Prefabricated Building in Libya. It then introduces the methods adopted for locations of the Study, interview Sampling, data collection, data analysis, and validity and reliability, which mainly include document analysis and semi-structured interview. Afterwards results and discussions are presented; finally, the paper draws the conclusion and future research.

**2. CONTEXT OF THE STUDY**

**2.1 Concept of Prefabricated Building**

The historical development of prefabricated building can be traced back to the 11th century [6]. However, prefabrication as a technique was adopted as early as the ancient times, as evidenced by Roman edifices and Greek settlement extensions in the Mediterranean Basin, including Libya, in 500 BC. The remains of monuments in Libya, particularly the temples and theaters comprised prefabricated marbles components that were transported from quarries that are dozens or even hundreds of kilometers away from the sites where they were erected [7]. Recently, new building methods have started to require the application of innovative materials and processes [8]. In 2009, more than 60 % of construction projects in Denmark, Sweden, the US, Japan, and Singapore were prefabricated [9].

Although different concepts, terms, and definitions are used to describe innovation in the construction industry, "*prefabricated building*" a term found by the author in the documents of Libyan government's late 1970s may serve as a good descriptor. According to Richard [10], “Prefabrication’ starts with the ‘pre,’ which means before and/or elsewhere". Thus, the core concept of offsite construction may be best depicted by prefabrication [11]. The term “building” can also be associated with prefabrication [12]. From both descriptions, “prefabricated building” can be defined as “the transfer of saving propositions of the manufacturing operations from the building site to factories or workshops, which may be independent or associated with the site” [13,14].

Studies demonstrated that the appropriate use of prefabricated building in the housing market has the potential to address certain key challenges that are faced by the housing industry, such as the limited supply of new homes [15], increased labor demand [16], high time and cost expenses [17,18], and defects in new housing [19]. In the context of limited utilization, indirect factors refer to the external forces that can improve or deter the status prefabricated building systems, such as policies, regulations, and reorganization of the industry chain. Singapore was the first Asian country to develop an industry code and regulatory framework for “buildability” [17]. In particular, the Building and Construction Authority initiated two rounds of discussion on the Construction Productivity Roadmap with the first one held in 2010 and the second in 2015. These initiatives aim to enhance the productivity of the local construction industry [20]. In Malaysia, "the National Council for Local Government mandated the private sector to construct prefabricated building for housing projects amounting at least 50 million to attain the minimum prefabricated building score of 50 by 2020. Meanwhile, the Ministry of Finance directed the public sector with projects valued RM10 million or higher to achieve the minimum prefabricated building score of 70 by 2018 " [21].

Many studies have listed the barriers of using prefabrication technologies in different contexts [e.g. 22, 23,24,25]. Moreover, the adoption of prefabricated building is still not the main priority of developing countries because the reasons behind its relatively high cost and complexity of applications have not yet been completely understood [26]. For a considerable understanding of the implementation of such technologies, recognizing not only the willingness of the construction industry in developing countries to innovate but also its awareness and appreciation as regards the impediments/barriers to be overcome is important. Amankwah et al. [22] identified hindrances to using prefabricated building in the Ghanaian construction industry. The low familiarity of stakeholders with the concept of its production and the low level of mechanization and construction technology in Ghana do not support its use. Rahimian et al. [27] concluded that a need exists for increased awareness, collaboration, training, and encouragement from the government for the adoption of prefabricated building in Nigeria. Aburas [28] highlighted the main barriers to the uptake on prefabricated building in the Saudi Arabian construction sector, namely, the lack of training and educational programs, negative perceptions, and the lack of roads and other infrastructures that support the transportation of oversized loads. A survey on the use of prefabricated building in Turkey and the US by Polat, [29] indicated that Turkish respondents ranked the lack of good communication among parties and the lack of structural engineers and contractors who specialize in precast concrete systems as important barriers to the use of prefabricated building in the Turkish market. However, these researchers proposed recommendations for the improvement of the use of prefabricated building in their respective countries.

**2.2 Prefabricated Building in Libya**

Steel structures have been utilized in schools, government facilities, and railways long before the independence of Libya in 1951. The use of precast concrete structures in Libya's sports sector goes back to the early 1960s. However, it was only in the early 1970s when these structures were employed in the public housing program, in particular, when the General Organization for Housing focused on speeding up the building of houses in the two major cities of Tripoli and Benghazi. When extensive internal migration into both cities began in the mid-1950s, two factories were constructed to manufacture the concrete components. Up to 1,200 apartments with four-storey blocks were annually estimated by each factory. The first factory was constructed in Benghazi in 1973 with a total cost of nearly $79 million and the second factory was built in Tripoli in 1974 with an overall cost of $135 million [30].

Prefabricated building systems adopted by the Libyan General Organization for Housing in the two aforementioned main cities were the French Tracoba and Danish Larsen Nielsen system types with load-bearing concrete walls. Prefabricated components accounted for 4.7% of the executed public housing parts and 2% of the executed private housing parts, totaling 156,067 constructed parts, from 1970 to 1978 [31]. However, the percentages were much lower than the plans (i.e., only 3,150 units were implemented of the target 7,000 flats) due to several obstacles, including the insufficient land area in Tripoli [32]. According to Stallen et al. [33] the most prominent causes of prefabricated building failure during the period were as follows: (1) high costs due to large fixed investments, (2) climatic unsuitability, (3) assembly problems, (4) physically non-adaptable buildings to subsequent changes of use, and (5) cultural unsuitability. Nonetheless, these problems did not prevent the imported technology’s penetration and diffusion into the local construction market.

Between the late 1970s and 1980s, apart from the housing sector, other sectors used the prefabricated building systems in the construction of their buildings; these projects were carried out by state-owned companies. Based on the classification of Majzub [34], the prefabricated building systems used in those projects fall into two major groups: (1) frame system (medium and heavy-weight frames with production material of steel or concrete), and (2) panel system (medium-weight panels with production of metal frame and composite materials, as well as heavy-weight panels produced in factories or onsite of concrete). Temporary volumetric structures (box-system) are commonly used in oil fields [35]. In the housing industry, the precast concrete panels system has predominantly adopted techniques that were imported from Italy, Denmark, Sweden, France, and Bulgaria, although the panel components are manufactured by using more than 80% of local materials.

The foreign companies largely supported the public companies’ growth through subcontracting or by providing technical assistance, mainly because local experience on the use of these construction methods, were lacking. However, most public companies failed to achieve successful technology acquisition due to insufficient government-implemented strategies, and this scenario resulted in the support withdrawal from these companies [32]. Since then, the uptake of prefabricated building in Libya’s construction industry has been limited. These projects have generally been implemented by foreign companies, except those by the National General Company for Manufactured Buildings (operated the precast concrete factory) in Tripoli and the General Company for Prefabricated Buildings (operated the precast concrete factory after which the factory was transformed into service markets, including the construction of administrative and school buildings and large multi-purpose halls) in Benghazi. Both companies remained operational until 2006. Subsequently, both companies and several public companies were merged into one company according to the government privatization framework of the public sector. The merged company has many branches and engages in conventional construction. However, the level of prefabricated projects managed by this company is 2% only.

**3. METHODOLOGY**

**3.1 Locations of the Study**

In research, generalizability refers to the extent by which the conclusions on the selected samples derived by the study can be applied to the wider population [36]. The selected sampling locations in this study are Tripoli (capital city) and Benghazi (second largest city). Tripoli and Benghazi are the two largest cities in Libya in terms of prefabricated building usage in addition to Al Bayda City, which has variable levels of usage. Nafoora, an oil field follows the Arabian Gulf Oil Company, was chosen as the model for the rest of the Libyan oil fields because prefabricated building is usually used in the preparation of these sites. The generalizability of the findings is increased by focusing on these sites to achieve relevance to all the Libyan cities.

**3.2 Interview Sampling**

The prefabricated building technology flourished among the Libyan public construction companies in the late 1970s and 1980s. Many experts who worked during that period can no longer be contacted due to retirement or their change in employment. Snowball sampling was used to access the ‘hidden population’ [37]. This method is suitable for this research given that the selection method begins by contacting a respondent (the starting point) and then asking him or her for endorsements of suitable respondents [38: p.81]. For example, starting from the social relations of the author with an engineer who used to work as the head of the National General Company for Prefabricated Buildings in Benghazi from 1978 to 1999, meetings were organized with a few other high-level officials who worked during that time in distant cities. Those officials then helped the author to contact other experts. When no new individuals were identified, we concluded process of the interview [39]. The snowball method further enabled the author to prioritize potential respondents who had substantial experience or have extensive interest on the research subject [40: p.142]. The two main criteria for respondent selection were as follows:

1) Experts must possess adequate knowledge on the field of prefabricated building; and

2) Experts should have first-hand experience on prefabricated building projects or have closely monitored the development of prefabricated building systems.

The author interviewed 21 experts from different organizations, all of whom worked on prefabricated buildings in the late 1970s and 1980s. Moreover, the author contacted five experts who currently hold similar positions in two operational public construction companies. Twelve engineers from the top-level management of the Projects Administration affiliated with the Health Ministry (Tripoli), Sports Ministry (Tripoli), Education Ministry (Tripoli and Benghazi), and Omar Al-Mukhtar University (Al Bayda), were also interviewed. The aforementioned sectors implement prefabricated building projects. Finally, four civil engineers from the top-level management of the Operations Administration of Nafoora were interviewed. Table 1 presents the participants and organizations, and their detailed information. The number of interviewees appeared insufficient to underpin new theoretical knowledge. However, Flyvbjerg [41] argued that important implications to enhance knowledge could be deduced despite small sample size given that the researcher was on a constant pursuit of the exemplary explanations. In addition, the relative importance of the implications is measurable. Moreover, the sample size could serve as a springboard for supplementary studies despite the small sample limitations [41, 42].

**3.3 Data Collection**

Mixed-mode interviews were conducted in person and follow-up interviews were conducted over the phone [43]. The first set of interview data was collected between March and June 2013 through semi-structured face-to-face interviews, which enabled the broad exploration of a topic [44]. Bryman [67] identifies semi-structured interview that it covers a wide range of instances: *"it typically refers to a context in which the interviewer has a series of questions that are in the general form of an interview schedule but is able to vary the sequence of questions. The questions are frequently somewhat more general in their frame of reference from that typically found in a structured interview schedule. Also, the interviewer usually has some latitude to ask further questions in response to what are seen as significant replies."* This description provided by Bryman [67] fitted the present research in terms of the design of interview questions, which are a list of general questions that have been formed as shown in Appendix A.

For retired participants, only one interview a day was conducted. All interviews were conducted in their homes. Presumed to be time-consuming, the actual time of the interview was restricted to 90 minutes. Setting appointments with interviewees who changed jobs or positioned at the top-level management of the Projects Administration was easy. Thus, two interviews were administered per day, and the interview period extended to 3 hours.

Given that Arabic is the dominant language of the participants, the interviews were administered in Arabic, taped, and eventually transcribed in NVivo software. The validity of Arabic-to-English translation was provided with meticulous attention. A comparison between the translated and original versions was performed to ensure accuracy and consistency. Compatibility between the back-translated and original versions is affirmed to indicate accuracy in translation [45].

The amount of gathered data was generally substantive, but a few aspects were found to be slightly vague and ill-defined during analysis. This research gap led the author to conduct the second-stage data collection to improve the reliability of the study. The second set of interview data were collected in 2015 through telephone interviews and e-mails (see Table 1). According to McNamara [46], initial interviews require a follow-up strategy for further investigation; in other words, on the basis of ongoing analysis, the subsequent interviews will be affected but may be directed to focus on emerging themes. Thus, based on the first-stage findings, the interview guide was slightly adjusted by adding retrospective information to sharpen the focus of the study themes.

**3.4 Data Analysis**

The NVivo (version 10) software can be used to consolidate information at a relatively faster pace than what is normally be required by manual data collection from taped interviews. The manual coding and analysis processes can be complex and can be a source of bias, while the use of the abovementioned software is a “safeguard” against any possible bias. Moreover, NVivo provides considerable flexibility in identifying codes and categories [47], by pulling out speciﬁc instances of words, phrases, or sentences and displaying entire sentences or paragraphs that contain the desired elements. In data abstraction or creation, coding simplifies the characterization of specific focal data [48]. Inductive content analysis was used in cases where no previous studies could be used as guide when classifying a given phenomenon, that is, coded categories were directly derived from text data [49]. A content analysis of the interviews was performed based on the method presented by Schmidt [50].

Open coding was conducted to obtain constructs for use in the axial coding procedure, and the constructs were classified into categories. For example, in the first stage, participants were asked to describe a positive perception of prefabricated building. An interviewee stated that prefabricated building components can be rapidly and accurately replicated, while a different respondent mentioned that the use of prefabricated buildings is the logical choice for the current housing shortage situation. Another interviewee pointed out that prefabricated buildings are beneficial to the production of high-quality buildings. These three interviews and those from others suggest the advantageous effect (a positive perception) on prefabricated building adoption. Accordingly, the authors decided to label these points as “clearly aware,” which appropriately represents the interviewees’ point.

Different themes were recognized from the textual data and were correspondingly coded into related themes. Codes were used to mark key points, which were grouped into similar concepts. Then, categories or themes were derived from the concepts. This strategy allowed the creation of an entire set of inductive coding frames that comprised main categories and subcategories. Finally, 10 themes that were classified into three major categories emerged from the dataset (Table 2).

**3.5 Validity and Reliability**

Qualitative research is criticized as biased, small-scale, anecdotal, and/or lacking rigor, but the opposite is true when it is carried out properly [51]. On the basis of the method presented by Fleming and Vanclay [52], the emerging interpretations were consistently checked against procured data from which they were derived to ensure relevance and validity in the themes. Generally, each theme was described and accompanied by representative direct quotations from in-depth interviews. These quotations are particularly important as they depict the researchers’ interpretation of the actual data, and application of the theoretical framework (if applicable) [53]. In addition, Rosenthal [53] contended that quotations should be presented in the Results section and not be presented as a table.

**4. RESULTS AND** **DISCUSSION**

The findings of the interviews are presented under the headings derived from the 10 themes within the three major categories as shown in Table 2. Figure 1 illustrates the screenshot of NVivo 10 that shows the codes on emergent themes of the data analysis.

**4.1 Background and History**

Although the many prefabricated building-related terminologies depict the contextual richness of the political, social, economic, and technological perspectives, the organizational context has been overlooked [54]. This organizational context can help explain the current need of the Libyan government to address the undersupply of housing and the industry requirements to improve quality performance.

To study the current and future utilization of prefabricated building, its history should be investigated in order to identify any regularity of its development rather than by examining their static, measurable characteristics. Lack of published studies that investigate the context of prefabricated building in Libya, led to the questioning of all participants to provide a brief outline/history and overview of the organization, as they relate to it. Such perspectives led to the inclusion of Section (2.2) in this study, and previously, the study of El-Abidi et al. [32] that presented the historical evolution and development of prefabricated building usage in Libya.

4.1.1 Government’s Role

The main role of enacting government policies to aid in the implementation of prefabricated components must be highlighted because the development of industrial practices is facilitated by governing institutions. Most of the interviewees reported that the Libyan government have not played a major role in the development of the construction industry. The government generally has a major role to endorse and strengthen institutional arrangements in accordance with the systematic planning and execution of national strategies and policies that will affect the construction industry. Accordingly, the overriding factor to the developmental transformation of the sector is committed of the government at all levels [55]. Shortages in the role of the Libyan government can be derived from the comments shared by two interviewees:

*“The output of the unlimited government support for public companies resulted in the booming of prefabricated building usage among these companies in the late 1970s and 1980s, but no proper plan was formulated by the government for this technology, which eventually led to industry failure” (an executive manager of NGCMB, T-Old).*

*“A positive step of the government was to facilitate the establishment of prefabricated building companies of many sectors, such as Housing and Utilities, Education and Vocational Training, Youth and Sports, and the Defense Sector until the late 1980s. However, these companies became a burden on their sectors due to lack of any progress” (a project manager of ALHMCC, T).*

The slow or lack of progress of the construction industry can be attributed to the absence of measurable targets for the programs aimed to enhance overall industry performance [56]. Moreover, the problems of the construction industry are complicated by various reasons, such as insufficient resources to implement the initiatives, government negligence toward the construction industry, and the lack of commitment to solve prevailing problems. A private sector strategy may be needed to realize enhance the current status of the industry. Accordingly, the success of public policies necessitates an integrated and systematic approach by which the usefulness of alternative policies can be forecasted on the basis of private sector’s response and foreseeable changes in the industry environment [57].

4.1.2 Technology Transfer and Acquisition

Several global research previously stated that technology transfer can improve productivity at the project, company, and industry levels, and it can advance the long-term economic growth of the host country [58,59,60]. However, in the present research, the interviewees claimed that the benefits of technology transfer cannot be easily achieved in the Libyan context owing to by barriers faced by Libyan public companies for prefabricated building.

Many Libyan public companies failed to realize successful technology acquisition. Most of them even ceased operations because of insufficient improvements and limited government-implemented strategies, which led to the removal of support for these companies. The operation of public construction companies was mostly supported by foreign companies in the form of subcontracting or technical assistance provision. Local construction companies were eventually detached from manufacturing and installation of prefabricated building components, and they instead concentrated on management and coordination functions and the marketing of products produced by the foreign companies. For example, the Arabic—Libyan—Hungarian Military Company encountered difficulty when the Hungarian Military Company withdrew from joint ventures for two years, as depicted by the following statement of an interviewee:

*“Although laborers remained and manufacturing and installation instruments were available, all projects of the Jebel Akhdar branch halted when the foreign partner left”(an officer of ALHMCC, JAB).*

The public sector’s dominance for nearly three decades engendered the weakness of local private firms. The General People's Committee, the Libyan equivalent of a national parliament, passed Decision 443/2006 to improve the performance of the private sector through joint ventures with foreign companies. Chatterji [61] describes technological acquisition as the generation of missing technological and managerial competence within companies in developing countries and the reduction of their long-term dependence on foreign capital, skills, and technology. The transfer of physical manufacturing structures and operational procedures was not considered as the main barrier, as pointed out by an interviewee:

*“Foreign partners clearly contributed in bringing advanced construction techniques, but local partners did not benefit from this partnership, as evidenced by the stopping of most projects after 2011. The major disadvantage is the lack of strategy by the government to measure the progress of these partnerships” (a consulting engineer of a PA).*

The government failed to effectively manage the construction industry in the 1980s and did not benefit from Decision 443/2006 on technological acquisition for the local companies. Thus, the organizational aspect and its related strategy formulation were the major barriers to the implementation of prefabricated building in the Libyan construction industry.

4.1.3 Corporate Leadership and Organizational Structure

Effective leadership is crucial in the formation of technological innovation, and technological competence is a key component of effective leadership of technological innovation [62]. In this regard, Winch [63] argued that hierarchical roles and functional delegation has valuable consequences on innovation. Leadership and support from the management are vital elements in dealing with cultural barriers and expediting the effort to change the status of the prefabricated building sector [64]. Successful leadership contributed to the long-term survival of the National General Company of Prefabricated Building. For example, when a French company handed over the precast concrete factory in Benghazi, four engineers were assigned by the General Organization for Housing to handle the factory, thereby forming the top management. The interviewee stressed the two main points:

*“The factory was transformed from a housing building into servicing facility for other markets. VALDIGI Company helped in the transformation of the factory and participated in the management of the company's first project (49 schools), which helped shape the structure of the company’s management departments. Meanwhile, the company benefited from the laborers of Daewoo Company who carried out the work. In the second project (21 schools), the company ran the project management on its own. The company then started training local laborers with support from Daewoo. Finally, the company operated independently since 1995” (the head of NGCPB, B- Old).*

*“The company developed the prefabricated components of the school projects to reuse them in administrative buildings, agricultural markets, and multi-purpose halls. This scenario resulted from the aspiration of the boardroom members to penetrate the market by targeting more than one sector” (a manufacturing manager of NGCPB, B- Old).*

Thus, the boardroom members of the National General Company of Prefabricated Building-Benghazi (NGCPB-B) successfully gained knowledge on the processes involved in technology life cycles and passed the knowledge down to subsequent members. This action contributed to the company’s success in the implementation of its current projects, as illustrated by the point shared by an interviewee:

*“Although the precast system of this project was new to the team, all the manufacturing and installation technicians of the project (1,164 one-story precast concrete houses) were local. Furthermore, the cooperation with Singapore’s Boustead Engineering Group was limited to the design and participation in the supervision of the schemes’ implementation” (a contract manager of NGCPB, B-New).*

The top management of the National General Company for Manufactured Buildings- Tripoli (NGCMB-T) followed a similar route in the management of the precast concrete factory in Tripoli. However, it demonstrated less evolution than the NGCPB-B, as noted by one participant:

*“Despite the major barriers encountered in the management of the company for the housing market, the boardroom members did not consider other sectors similar to how their counterparts in Benghazi handled the situation. The problem was further compounded when the Ministry of Housing was dissolved, which led the engagement of the company to manufacture simple precast concrete products, such as fences for buildings, road barriers, and rectangular planters” (a project engineer of NGCMB, T-Old ).*

On the basis of this case study, NGCPB-B and NGCMB-T seemed to be more ready and capable to continue and improve prefabricated building processes than other state-owned companies. Both companies’ separation from the Ministry of Housing resulted in independent decision making. This finding was confirmed by one of the principal themes in prefabricated building management in Libya, namely, the leadership from the top-level management of the companies. Leadership is associated with the delegation of roles in the organization, and the organization is hierarchically structured with multi-skilled managers.

4.1.4 Prospective Practitioners Awareness

Awareness of prospective and active professionals about the nature of prefabricated buildings, its capabilities, and the technology’s wide range of applications can assist in the distributed use of prefabricated building systems [65]. The interviewees argued that increasing the awareness on this pressing issue on operational speed (i.e., time-saving aspect) still requires strict adherence to the use of prefabricated building methods. However, the cost issue, which is also an urgent concern, has limited the development of prefabricated buildings, as shared by an interviewee:

*“The importance of prefabricated buildings has shifted considerably toward the cost aspect. Customers were prepared to reduce the time required to construct their buildings as long as the projects are cost effective” (a project engineer of GCMMF,T).*

Many respondents commented that the lack of knowledge and awareness among prospective practitioners is a major hindrance to the adoption of the technology. As stated by one interviewee:

*“The lack of information and knowledge on prefabricated building practices led to their negligence in Libya unless they are the implementation methods of a few foreign companies or are required by a few sectors to speed up their projects” (the head of a GCO).*

4.1.5 Affordability

A general agreement exists among most of the respondents that the usage of prefabricated building does not generate higher savings compared with the conventional construction methods, as exemplified by one interviewee:

*“Regardless of factory cost and transportation, prefabricated components are designed with sufficient steel reinforcements and engineered with strong concrete bearings to withstand the rigors of transport and lifting. Such design increases the overall cost of the structure of the building” (a manufacturer manager of* *NGCMB, T-New).*

**4.2 Drivers for Using Prefabricated Building in the Housing Sector**

4.2.1 Prefabricated Building Exploitation to Improve the Housing Industry

The participants believe that prefabricated building can improve the Libyan housing industry and produce better quality housing at a faster completion rate than by using conventional methods. Numerous external factors, such as unstable business, shortage of labors and materials, and unbalanced distribution of resources, currently affect the Libyan construction industry. The participants offered an assumption that can drive the uptake of prefabricated housing, as illustrated by the following comments:

*“Since the 1980s, the number of completed housing units was on a downward trend. This reason is associated with the rapid population growth and the large-scale internal migration from rural to urban areas, which also affect the adequacy of public services in these areas”* *(the head of a PA).*

*“Libya experienced a civil war in 2011, which was followed by political conflict. A considerable number of houses have to be rebuilt to accommodate the displaced population” (a project engineer of GCCMMF, EPB).*

However, a new approach to the usage of the technology has created an inflexible perception, which negatively impacts its potential implementation in the housing industry, as illustrated in the following comment:

*“The new factories that have been established by the private sector three years ago are considered a center for the assembly of components (imported from Turkey or Italy) into units, which are then transferred to the site. These products mainly targeted the people who have left their homes in conflict zones, but these homes are considered temporary solutions to their” (the head of* *NGCPB, B-New).*

4.2.2 Users' Attitudes and Traditions

The products of precast concrete factories (closed system) in the two major cities of Benghazi and Tripoli in the 1970s had a poor image due to their unsuitable design for local cultural habits. These products also suffered from sound penetration; they continue to be considered “housing for the poor community.” However, a change in the perception toward the technology imported by foreign companies (open system) since the 1980s has been observed. In most countries, users’ attitudes and traditions are usually influenced by the rise of the welfare state. However, this scenario is nearly nonexistent in Libya (according to a few participants), resulting from the severe shortage of housing stock. Such perspective was derived from the interviewees’ responses. For example,

*“A wide gap exists between demand and supply of residences, and the undesirable type for one social class is strongly desirable for another class” (the head of OMNF).*

However, a clearer attitude toward the new factories managed by the private sector has become evident after 2011. People are prejudiced toward these factories, and their social and cultural acceptances are still uncertain at this stage, as shown by the following comment:

 *“Wood and metal are not conventional building materials in Libya. They are low-value commodity products with a shorter life cycle compared with brick and concrete” (a manufacturing manager of NGCPB, B- Old).*

4.2.3 Sustainability

Legislative requirements from the Libyan government geared toward the energy conservation of buildings for new housing projects have been enacted since 2006 [66], but the means and methods to achieve this scheme are generally left to the contractors, as shown by the following quote:

*“Defects related to the energy consumption of buildings occur because of poor design or low-quality workmanship. For the first cause, the government followed design strategies that can successfully avoid the defects, including aligning material performance to different weather conditions. However, the second cause is still prevalent” (the head of a PA).*

High-level standards and codes can be sourced internationally, but they are designed for a specific country based on its local conditions. Libya’s huge land area has three different climatic conditions; however, the different climatic criteria were not considered in the design of buildings constructed before 2006. The government is the predominant client of the housing sector; thus, this situation should be regarded as the starting point of sustainability of the sector. This would make prefabricated building an ever-stronger by creating more sustainable building activities. One participant (*a consulting engineer of a GCO*) mentioned:

*“Prefabricated building deals with issues of energy efficiency and the environmental impact of construction work onsite. Its low conductivity and good insulating properties render it superior to conventional construction methods in resisting heat or cold flows, thus generating substantial savings in terms of energy consumption.”*

4.2.4 Government Support

The adoption of prefabricated building by the private sector requires high capital costs to import machinery/molds and set up factories for manufacturing building components. Therefore, providing support, especially from the government, contributes to the appeal of this option. Unlike in several countries, Libya can offer this support because small and medium enterprise development has been emphasized in the Libyan government agenda, and funding support is provided through the Development Bank-Libya. The respondents stressed that bank financing of general contractors has been a key development strategy for local companies since 2006. A similar concept can be drawn from the following statement:

*“Development Bank-Libya provides loans for the manufacturing of building materials. This type of financing is applicable to the establishment of prefabricated building components of factories. Another aspect is the financing of the imported cranes and trucks for the quarrying industry, which can be applied to the transport and installation companies of prefabricated building” (a project manager of NGCMB, T-New).*

The upscaling of worker skills is an enormous challenge due to the nature of the labor market in Libya. The insufficient number of joint ventures for prefabricated building projects is also one of the hindering factors that exacerbated the situation with regard to training plans. Furthermore, these joint ventures are unreliable to support the industry, as suggested by one interviewee:

*“Joint ventures between local and foreign companies offer part of the training but only on a limited scale and without including all industry disciplines” (the head of GCMMF,T).*

The provision of education and training at all levels in the industry is necessary to meet future skill/expert requirements, because a wide skill base will be required from designers and installers alongside the knowledge offered by expert consultants and manufacturers. Thus, strong leadership and government support at all levels are needed to facilitate prefabricated building usage in the housing sector.

**4.3 Providing Tentative Guidelines for Prefabricated Building Implementation**

4.3.1 Draw a Conceptual Framework

Although the benefits of using prefabricated building has been well recognized, the implementation process requires drawing up a framework to foster understanding of the concept and render a careful review of how to realizing those benefits. An important component of the framework is the guidelines, which can help increase awareness on the regulatory processes involved developing and driving prefabricated building usage. The background of the Libyan construction industry, particularly in the initial stage of prefabricated building implementation, has bring forth hesitations on the suitable categories and criteria for the framework that should be used to formulate tentative guidelines.

Although nearly two-thirds of the interviewees believe that guidelines are necessary to use this technology, their views were incomplete or off-base because local experts are uncertain about the nature and quality of the required regulatory components. Benefiting from the experience of other countries has been a common trend for many sectors in Libya after 2011 as a means to resolve their shortcomings. Some of the interviewees shared that prefabricated building implementation will be unsuccessful without learning from the experience of other countries.

**5. SUMMARY OF RESULTS**

The interviews provided information on the challenges and opportunities concerning the application of prefabricated building to construct housing units in Libya. The study finding that the offer of prefabricated building to building structures of projects does not the cost-efficient alternative. Clearly, an overall positive attitude exists toward faster completion of housing structures through value-added, prefabricated building products. Another interesting finding is that the analyzed interviews affirm that technical issues are less critical than organizational strategies in preventing the Libyan industry from embracing prefabricated building. However, majority of the interviewees were unsure of how to provide conceptual guidelines that could be considered as a starting point for evolution and much-needed prefabricated building drives.

According to the respondents, the major incentives of using prefabricated building (i.e., as a construction paradigm) to address future housing shortages include easing the labor requirement pressure, meeting the increasing housing demand, and improving the quality of finished products. In addition, experts generally agree that the government plays a critical role in the promotion and development of prefabricated buildings. Moreover, the government is considered a major driver in embracing such a technology. Table 3 shows the summary of the interview results.

This paper contributes to the existing studies on prefabricated building. It focuses on Libya, a country that continues to suffer from the lack of organization of the industry. To bridge the research gap, we aim to provide the reference into prefabricated building in Libya and other countries that experience similar difficulties. In order to catch up, these countries (including Libya) can benefit from the experiences derived from periods of regulation in developing countries and have reached a marked stage in the development of their construction industry.

1. **LIMITATIONS OF RESEARCH**

1. Given that a detailed study on prefabricated building in the Libyan construction industry has been scarce, this study is the first attempt to explore such technology. This paper is preliminary results to study how to resettle prefabricated building in Libya, it could serve as a springboard for supplementary studies.

2. The adoption of prefabricated building was not given the top priority in developing countries, thus finding valid sources of comparison on it is quite difficult. The work even complicates further when the subject of the research was the investigation of the effect of using prefabricated building instead of conventional methods on cost and time as percentages in general in Libya and other developing countries. As a result, the lack of comparison of the results with other developing countries is one of the limitations of the present study.

3. The shortage of data on the percentage of using prefabricated building owing to the limited published statistics in developing countries. Thus, the lack of information on the percentage of implementing prefabricated building in these countries is to be regarded as a research limitation.

**7. CONCLUSION AND FUTURE RESEARCH**

This study aimed to increase the understanding of the current situation of prefabricated building and its potential as a method to improve the housing segment of the construction industry. Semi-structured interviews and inductive content analysis were used. This study applied the snowball sampling technique, and the interviewees comprised experts from the top administrative, management and professional levels. Despite the relatively small sample size, this study is the first attempt to explore prefabricated building technology in Libya. The NVivo (version 10) software was used to aid in the organization and analysis of data obtained from taped interviews.

On the basis of the semi-structured interviews and their content analysis, the results show that Libyan experts recognize the importance of adopting prefabricated building in the Libyan housing industry. However, they believe that the government and prospective practitioners generally lack information, knowledge, and experience on prefabricated building application, as evidenced by the strong prejudice toward their use. The interviewees also recognized that the implementation of this technology may be unattainable, yet the quest to achieve its usage may be realized if proactive steps are undertaken.

A conceptual basis for the formulation of practical solutions is necessary. Consequently, the factors that are critical to the success of prefabricated building application of another country which has an established industry should be explored. Such an action will allow Libya and other countries (that experience similar difficulties) to formulate future strategies that can enable progress from conventional practice toward the use of prefabricated buildings as a mainstream construction method.



Figure 1: Screenshot of Nvivo 10 showing the codes on emergent themes

 Table 1. Details of the participants and organizations, and their detailed information

|  |  |  |
| --- | --- | --- |
| Code | Organization | Number ofParticipants |
| Year | 2013 | 2015 |
| NGCPB, B- Old  | National General Company for Prefabricated Buildings, Benghazi. They worked during the late1970s –1980s  | 3 | 1 |
| NGCMB, T-Old  | National General Company for Manufactured Buildings, Tripoli. They worked during the late1970s –1980s  | 2 | - |
| GCMMF, T  | General Company for Construction and maintenance of municipal facilities, Tripoli. They worked during the late1970s– 1980s | 2 | - |
| GCCMMF, EPB  | General Company for Construction and maintenance of municipal facilities, Eastern Province branch (Benghazi). They worked during the late1970s –1980s  | 3 | 2 |
| ALHMCC, T  | Arabic—Libyan—Hungarian Military Company for Construction (Tripoli). They worked during the 1980s–the early 1990s  | 3 | 1 |
| ALHMCC, JAB | Arabic—Libyan—Hungarian Military Company for Construction, Jebel Akhdar branch (Al Bayda). They worked during the 1980s–the early 1990s  | 1 | 1 |
| GCO  | Government consultation offices (Tripoli, Benghazi and Al Bayda). They worked during the late 1970s–the early 1990s  | 7 | - |
| NGCPB, B-New | National General Company for Prefabricated Buildings, Benghazi | 3 | 2 |
| NGCMB, T-New  | National General Company for Manufactured Buildings, Tripoli.  | 2 | 1 |
| OMNF  | Operations Management in Nafoora field subsidiary of the Arabian Gulf Oil Company  | 4 | 2 |
| PA  | “Projects Administration” affiliated to the Health Ministry, the Sports Ministry, the Ministry of Education (Tripoli and Benghazi), and Omar Al-Mukhtar University (Al Bayda). | 12 | 3 |
|  | **Total** | **42** | **13** |

Table 2. Thematic framework of data analysis.

|  |  |  |
| --- | --- | --- |
| Major categories | Themes | Properties or dimensions |
| 1. Background and history of prefabricated building | 1) Government role | Government leadership and commitment |
| 2) Technology transfer and acquisition | Government-implemented strategy |
| 3) Corporate leadership and organizational structure | Corporate leadership and technological competence |
| 4) Prospective practitioners awareness | Knowledge and consciousness of prospective practitioners |
| 5) Affordability |   |
| 2. Drivers for using prefabricated building in housing sector | 1) Prefabricated building exploitation to improve the housing industry | Meeting the housing demand |
| 2) Users' attitudes and traditions | Prefabricated building reputation and cultural acceptance |
| 3) Sustainability | Supportive standards, legislation, guidelines and assessment systems |
| 4) Government support | The provision of finance and training |
| 3. Providing theoretical guidelines to embrace prefabricated building | 1) Draw a conceptual framework | Re-localization of prefabricated building over a long time |

Table 3. Summary of the interviews results

|  |  |  |  |
| --- | --- | --- | --- |
| Major categories | Themes | Further clarification of dimensions | Important current issues |
| 1. Background and History of Prefabricated Building | 1) Government role | The government commitment is overriding factor in initiating change | • Lack of resources and initiatives• Lack of commitment to solve construction industry problems. |
| 2) Technology transfer and acquisition | Acquisition of new technologies and ensure their continuity | • Lack of strategy by the government• Joint venture with systematic binding |
| 3) Corporate leadership and organizational structure | The importance of hierarchical roles | • Lack of available knowledge of prefabricated building |
| 4) Prospective practitioners awareness | Major hindrance to technology adoption | • Lack of knowledge and awareness• Awareness of cost issue restricting the adoption of prefabricated building |
| 5) Affordability | Increasing concern for affordability | * Awareness of cost issue restricting the development of prefabricated building
* Considering prefabricated building in terms of value for money
 |
| 2. Drivers for Using Prefabricated Building in Housing Sector | Prefabricated building exploitation to improve the housing industry | Driving the uptake of prefabricated building | * Downward trend of completed housing
* Accommodating the displaced population
 |
| Users' attitudes and traditions | Increasing preference for prefabricated building | • Different levels of perception• Limited acceptance of prefabricated building products |
| Sustainability | Sustainability is a major driver | • Changes in standards related to thermal insulation and conservation |
| Government support | Making prefabricated building more attractive option | • The need for developing financial-human resources |
| 3. Providing Theoretical Guidelines to Embrace Prefabricated Building | 1) Draw a conceptual framework | Blurred vision in creating strategy | • Lack of measures to guide prefabricated building development.• Benefiting from other countries experience |

**APPENDIX A: SEMI-STRUCTURED INTERVIEW**

 **List of General Questions**

Please note that the script was used as guidance and each interview took its own course, with some issues being more elaborated upon than others, depending on the interviewee’s take on them.

**Section 1**

**Personal details**

I would be grateful if you answer some information about yourself and your level of experience in prefabricated building.

1- Could you please tell me what age category you fall in?

|  |  |
| --- | --- |
| A | 30-40 |
| B | 41-50 |
| C | 51-60 |
| D | 60+ |

2- What are your academic qualifications?

|  |  |
| --- | --- |
| A | Primary |
| B | Secondary |
| C | University degree |
| D | Postgraduate |
| E | Other |

3- If your answer is E specify. ...............................................................

4- If your answer is C or D, specify your field of specialization.

|  |  |
| --- | --- |
| A | Engineering |
| B | Economics |
| C | Accounting |
| D | Management |
| E | Other |

5- If your answer is E specify. ...............................................................

6- How many years of professional experience have you had?

|  |  |
| --- | --- |
| A | 5 - 10 |
| B | 11 - 15 |
| C | 16 - 20 |
| D | 21+ |

7 -What is your position in your job?

|  |  |
| --- | --- |
| A | Director / CEO |
| B | Consultative Manager |
| C | Contract Manager |
| D | Developer |
| E | Other |

8- If your answer is E specify. ...............................................................................

**Section 2**

**Background and history**

1- Please provide a brief outline/history and overview of the organization, which you relate to it.

**Section 3**

**Current situation**

1- What is the current situation of prefabricated building in Libya? (Please cite examples wherever possible).

**Section 4**

**Challenges and key drivers**

1- What are the main challenges and key drivers affecting the use of prefabricated building in the Libyan housing sector? (Please give examples from actual events and your experience).

**Section 5**

**Providing Tentative Guidelines to Use Prefabricated Building**

1- How should tentative guidelines be provided to embrace prefabricated building?

2- Could you classify the activities which make up a framework into key groups, with an explanation that identifies the sub-activities inside each main group?

***THANK YOU VERY MUCH FOR COMPLETING THE QUESIONNAIRE.***

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